

between 300 and 1700 nanometers (nm). A similar SSFR was deployed at a ground site to obtain downwelling irradiance at the surface. The data will be used to determine the net solar radiative forcing of dust and other aerosols, to quantify the solar spectral radiative energy budget in the presence of elevated aerosol loading, to support satellite algorithm validation, and to provide tests of closure with in-situ measurements.

In August/September 2000, Ames personnel participated in the South African Regional Science Initiative (SAFARI 2000), an international science initiative aimed at developing a better understanding of the southern African Earth/atmosphere/human system. The goal of SAFARI 2000 is to identify and understand the relationships between the physical, chemical, biological and anthropogenic processes that underlie the biogeophysical and biogeochemical systems of southern Africa. Particular

emphasis will be placed upon biogenic, pyrogenic, and anthropogenic emissions, their characterization and quantification, their transport and transformations in the atmosphere, their influence on regional climate and meteorology, their eventual deposition, and the effects of this deposition on ecosystems.

During SAFARI 2000, the SSFR was deployed on the NASA ER-2, the University of Washington CV-580, and at a ground site in Kruger National Park. Data will be used to characterize the spectrally dependence of cloud and aerosol radiative forcing.

Maura Rabbette and John Pommier, Bay Area Environmental Research Institute and Steve Howard, Symtech Corporation, collaborated with the Ames investigators on this project.

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## In-Situ Measurement of Particle Extinction

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Aerosol optical properties are extremely important in assessing climate change. The lack of sufficient knowledge of aerosol optical properties and their variability in the atmosphere have led the Intergovernmental Panel on Climate Change to rate the effect of aerosol as the most uncertain of all parameters considered important to climate change. Currently, these aerosol properties are obtained from filter samples that measure absorption of black carbon aerosols on a time scale of tens of minutes to hours. Aerosol variability causes significant changes in optical properties on the order of seconds, especially when sampled from aircraft. Thus, the research community is very interested in an instrument that can measure the optical properties of all aerosols,

not just black carbon, on a time scale of seconds. The instrument developed by a commercial vendor can meet these expectations and has the capability to revolutionize the measurement of aerosol optical properties.

Ames is working with the vendor to develop an innovative instrument using cavity ring-down absorption spectroscopy (CRDS) to measure the extinction and scattering coefficients of aerosol, and consequently, the single-scatter albedo. The prototype instrument demonstrates: (1) fast and accurate measurement of aerosol extinction, (2) measurement of aerosol scattering in a CRDS system, and (3) simultaneous measurement at two laser wavelengths. The instrument proved capable of measuring

the extinction of ammonium sulfate aerosol typical of the mid- to high-troposphere background aerosol. At the same time, the scattering of the aerosol was measured, and an estimate of its single-scatter albedo could be made. It is expected that continued development of this technology will lead to a flight-ready instrument within the next two years.

T. Owano, Informed Diagnostics, Inc., collaborated on this project.

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## The Runaway Greenhouse Effect on Earth and Other Planets

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Water vapor is an efficient absorber of outgoing longwave infrared radiation on Earth and is, therefore, a primary greenhouse gas. Since the amount of water vapor in the atmosphere increases with increasing surface temperature, and the increase in water vapor further increases the temperature, there is a positive feedback. The runaway greenhouse effect occurs if this feedback continues unchecked until all the water has left the surface and enters the atmosphere. For Mars and Earth, the runaway greenhouse effect was halted when water vapor became saturated with respect to ice or liquid water, respectively. However, Venus is considered to be an example of a planet where the runaway greenhouse effect did occur, and it has been speculated that if the solar luminosity were to increase above a certain limit, it would also occur on Earth.

Satellite data acquired during the Earth Radiation Budget Experiment (ERBE) clear sky conditions shows that as the sea surface temperature (SST) increases, the rate of outgoing infrared radiation at the top of the atmosphere also increases, as expected. Surprisingly, above 300 kelvin (K) the outgoing radiation emitted to space actually decreases with rising SST. Less energy to space implies that more energy is available to heat the surface, leading to a potentially unstable situation. This behavior is a signature of the

runaway greenhouse effect on Earth. However, the SST never exceeds 303 K, thus the system has a natural cap that stops the runaway.

According to Stefan-Boltzmann's law, the amount of heat energy radiated by the Earth's surface is proportional to temperature ( $T$ )<sup>4</sup>. However, if the planet has a substantial atmosphere, it can absorb all heat radiation from the lower surface before the radiation penetrates into outer space. Thus, an instrument in space looking at the planet, does not detect radiation from the surface. The radiation that it detects comes from some level higher up in the atmosphere. The effective temperature ( $T_e$ ) is the temperature of this emitting region within the troposphere; lower levels may have much higher temperatures. On Earth the average temperature of the surface is 288 K, but the effective temperature is only 255 K. The value  $T_e = 255$  K corresponds to the middle troposphere, above most of the water vapor and clouds.

Atmospheric instruments and sensors on high-altitude aircraft, radiosonde, and satellite platforms provide direct observations of sea-surface temperatures, outgoing infrared flux to space, and atmospheric humidity and temperature profile measurements. The ERBE data is now being used to model the sea-surface temperature and outgoing flux to space. The aim is that this radiative transfer model will